Water Resources of the Raft River Basin Idaho-Utah

By R. L. NACE and others

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WATER RESOURCES OF THE RAFT RIVER BASIN, IDAHO-UTAH

By R. L. NACE and others

ABSTRACT

Much arable land in the Raft River basin of Idaho lacks water for irrigation, and the potentially irrigable acreage far exceeds the amount that could be irrigated with the estimated total supply of water. Therefore, the amount of uncommitted water that could be intercepted and used within the basin is the limiting factor in further development of its native water supply. Water for additional irrigation might be obtained by constructing surface-storage works, by pumping ground water, or by importing surface water. Additional groundwater development is feasible. As an aid to orderly development and use of the water supplies, the report summarizes available geologic and hydrologic data and, by analysis and interpretation, derives an estimate of the recoverable water yield of the basin.

The Raft River basin includes about 1,560 square miles, of which about 360 is in the Raft River valley. Most of the irrigated and irrigable land lies in the lower Raft River valley and an adjacent section of basalt plain south of Lake

The Raft River basin is a mountain-and-valley area in which rugged mountain ranges rise boldly above the aggraded alluvial plains of intermontane valleys. Topography and geologic structure strongly influence the climate and hydrology of the basin. The Raft River, the master stream, rises in the Goose Creek Mountains of northwestern Utah and flows generally northeastward and northward, joining the Snake River in the backwater of Lake Walcott, a Federal reclamation reservoir in the Snake River Plain.

The climate of the Raft River basin ranges from cool subhumid in the mountains to semiarid on the floor of the Raft River valley. Precipitation ranges from 10 to 12 inches on the valley floor to more than 32 inches at some places in the mountains. Rainfall is light during the growing season and irrigation is necessary for most cultivated crops. The mean annual temperature in the central lowland is about 45° to 48° F. The estimated average rate of evaporation from lowland free-water surfaces is slightly less than 41 inches per year. The average relative daytime humidity in the lowland in summer probably is about 25 percent.

About 43,000 acres of land is irrigated, most of it in the Raft River valley. Nearly all usable surface water in the basin is diverted for irrigation and about 18,000 acres is irrigated exclusively with surface water. Most stock, farm, and domestic water is from wells. Irrigation with ground water is widely practiced and 25,000 acres was irrigated partly or wholly with ground water in 1954.

Although much information is available about the geology of the basin, it is not sufficiently detailed to permit a complete analysis of the complex interrelations of the geology, climate, and hydrology. The Raft River basin has a complex structural, geologic, and physiographic history. The landforms and the geologic structures control the surface drainage pattern as well as the occurrence and movement of ground water. The principal water-bearing materials in the area are volcanic and lake deposits of the Salt Lake (?) formation, the Raft Lake beds, unnamed deposits of alluvial gravel and sand, and the Snake River basalt. Large-scale development of ground water would be possible only in the Raft River valley; therefore, only those geologic features that are most closely related to the occurrence of ground water in the valley are discussed. Nevertheless, much geologic information that is omitted from the report was considered in the hydrologic interpretations.

The estimated total volume of water contributed to the Raft River basin by precipitation is 1,290,000 acre-feet per year. Potential evapotranspiration, calculated by the Thornthwaite method for three locations in the valleys of the basin, ranges from 22.5 to 24.4 inches yearly. Actual evapotranspiration is much less because of the natural water shortage, and the estimated average for the entire basin is about 13.3 inches per year. The estimated total volume of actual evapotranspiration from the entire basin is 1,105,000 acre-feet yearly (not adjusted for increased consumptive use on irrigated land). This estimate is derived by a new method, not previously published. The method minimizes some of the consequences of unavoidable errors, which tend to be magnified in the Thornthwaite method.

Although potential evapotranspiration is about twice the precipitation in lowland areas, not all the precipitation is consumed. Precipitation is distributed unevenly through the year; runoff and recharge occur during periods of local and temporary excess of water. The excess of precipitation over actual evapotranspiration, averaged for the entire basin and called the water yield, is about 2.2 inches. This value is computed by methods explained in the report.

The Raft River discharges about 17,000 acre-feet of water yearly from the part of its watershed that lies above The Narrows. Below The Narrows the river alternately loses and gains water by seepage into and out of the ground. Most of the surface water is diverted for irrigation and the discharge of the river at its mouth is less than 10,000 acre-feet yearly. The unused surfacewater yield of the basin therefore is only a small fraction of the total water yield.

Ground water occurs under both water-table and artesian conditions. Most of the readily accessible unconfined ground water of good quality occurs at shallow depth in alluvium below The Narrows and north of Strevell, and in basalt in the Northern Plains section. The Raft lake beds also are aquifers but their extent is not known. Artesian water occurs in the Salt Lake(?) formation, which is presumed to underlie most of the lowland in the Raft River valley. A water-table map of the central valley lowland shows that the slope of the water table ranges between 10 and 40 feet per mile in a general northward direction, and the depth to water is less than 50 feet in a narrow bett adjacent to the Raft River. In the northern section, or basalt plains, the depth to water is as much as 300 feet, and in places perhaps more.

Systematic observations have been made of water-level fluctuations in parts of the basin since 1948. In upland areas water levels are lowest in winter and early spring and highest in late summer. In the irrigated lowland of the Raft River valley water levels rise to their highest stage early in the irrigation

season, but drop soon thereafter. The yearly water-level fluctuations range from 1 or 2 feet in some lowland areas to 25 feet or more at higher altitudes. Despite recent increased pumping of ground water, there was no noticeable net decline of water levels from 1948 through 1950, even in heavily pumped areas.

Ground water is recharged in the Raft River basin by direct penetration of precipitation, by inflitration from streams, and by inflitration of irrigation water. Ground water in valley lowlands is replenished also by underflow from adjacent highlands. The ultimate origin of the water from all these sources is precipitation. Unconsumed precipitation, estimated to be about 184,000 acre-feet yearly, is divided between surface runoff and ground-water recharge. Very little runoff reaches the Snake River, so nearly all unconsumed water becomes ground-water recharge at some place above the mouth of the Raft River. Locally, as in the valley of the Raft River above The Narrows, the volume of runoff is appreciable.

Some ground water is discharged to streams, but these in turn lose some water to the ground. Owing to the complexity of relations between ground water and surface water, it is not realistic to treat the two separately.

The chemical quality of water in the Raft River basin is important in irrigation because some of the water is doubtful to unsuitable for the types of soils in the arable areas. The chemical quality varies widely and needs much additional study. The temperature of the ground water varies widely. Most is between 48° and 60° F but some is as warm as 211° F.

Pumpage of ground water increased tenfold from about 8,700 acre-feet in 1948 to 64,000 acre-feet in 1955. The amount of land irrigated with the water is not known because some land is irrigated with a combination of ground and surface water. In addition to the volume of evapotranspiration in the basin. which is computed to be 1,105,000 acre-feet yearly in the natural state, the 35,000 acres of irrigated cropland in the Raft River valley consume about 39,000 additional acre-feet of water; 8,000 acres in the Yost-Almo basin consume 5,000 additional acre-feet. The net consumptive use, therefore, is nearly 1,150,000 acre-feet. The unconsumed residual water yield of the whole basin is about 140,000 acre-feet. Less than 10,000 acre-feet leaves the basin by surface flow at the mouth of the Raft River; the rest leaves the basin by underflow. The loss in the Raft River is compensated partly by infiltration to the Northern Plains section from the bed of Lake Walcott. The uncommitted water supply of the basin, therefore, is assumed to be the same as the unconsumed residual water yield-140,000 acre-feet, in round numbers. The recoverable and usable part of that supply is the limiting factor in any further development of the basin with its native water supply.

The lowland area of the Raft River valley alone contains about 386,000 acres of undeveloped land. But if only 100,000 acres is irrigable the consumptive-use demand for its irrigation would be about 111,000 acre-feet per year in addition to the existing natural consumptive use. The total diversion or pumping demand would be 200,000 to 300,000 acre-feet, or far more than the estimated available supply of unconsumed and uncommitted water. Much of the unconsumed pumped water would return to the ground-water body within the area of use and be recirculated. The net pumping demand, therefore, would be much less than 200,000 acre-feet and probably not much more than 111,000 acre-feet. Hydrologic factors that would limit recovery and use of the water are the capacities of the aquifers to yield water to wells, the amount of water that wells or other structures can intercept, the effects of new pumping on established water rights, and the suitability of the water for irrigation.

Successful irrigation wells in the Raft River valley have specific capacities ranging from a few to 312 gpm (gallons per minute) per foot of drawdown, and are pumped at rates of about 90 to 3,125 gpm. The coefficient of transmissibility, as determined by pumping tests at two sites, is about 180,000 gpd (gallons per day) per foot. Estimates by other methods indicate an average of about 200,000 gpd per foot, but this probably represents only about the upper 200 feet of the aquifers. Similar aquifer characteristics undoubtedly prevail at many places in the valley. The general ability of the aquifers to accept recharge readily and to transmit water freely is evident.

Not all the available ground water could or should be intercepted by wells. If it is assumed that a pumping season lasts 120 days, during which wells are being pumped 18 to 24 hours per day, the pumping time would be equivalent to about a third of each year or less. Underflow of ground water out of the valley, however, occurs the year round, and even during the pumping season not all the underflow could be intercepted. Enough water—50,000 to 75,000 acre-feet—might be intercepted for the diversion demand of 25,000 to 30,000 acres of land. By temporary overpumping from strategically located wells during each irrigation season, a larger percentage of water would be recovered than if wells were pumped less. These and other estimates undoubtedly will be revised as development proceeds and more information becomes available.

The pumping of 75,000 additional acre-feet of water for irrigation would nearly double the 1955 pumping demand for water, and total pumpage would be about 160,000 acre-feet per year. The total acreage irrigated with ground water and surface water would be about 73,000, for which the consumptive-use demand not already accounted for as natural consumptive use would be about 81,000 acre-feet, or about 44 percent of the total natural water yield of the basin. This demand probably would not exceed the safe water yield of the basin, because the unconsumed pumped water would be available for return-recharge of ground water.

With proper management of the total water supply, whether from the ground or surface streams, new development on the scale indicated might entail local competition for water. Regional competition with users outside of and downstream from the Raft River basin would be negligible. If optimum development of all water in the Raft River basin is to be achieved, it may be necessary to manage and utilize all the water as a single resource. Perhaps water rights could be broadened to apply to any water, whether from the ground or from surface streams.

Logs of 81 wells and tabular records of the characteristics of nearly 400 wells, are given at the end of the report.

INTRODUCTION

PURPOSE AND SCOPE

The purpose of studies in the Raft River basin was to estimate the total water yield of the basin, the parts of that yield that are available as surface water and ground water, the amount of ground water that might be recovered for beneficial use, and the effect of such use on downstream water supplies.

Much arable land in the Raft River basin lacks water for irrigation. The basin contains only one small surface-storage reservoir, and nearly all the surface water discharged by streams during the irrigation season is appropriated. Supplemental water for old land and a supply for new land could be obtained only by constructing surface-storage reservoirs, by pumping ground water, or by importing water. The amount of surplus winter and flood runoff may be too small to justify storage. Moreover, surface storage would not solve the main problem in the valley, which is that the total water supply is not adequate for all the undeveloped irrigable land. Water might be imported from the Snake River but that possibility seemingly has not been studied. Many irrigation wells have been drilled in the Raft River valley since 1948, and more are in prospect.

For ground-water development and use to be orderly, with due attention to the problem of the total water supply, basic hydrologic information is needed by water users, by State and local officials who administer water rights, and by Federal agencies who are concerned with land and water use. The amount of ground water that might be used for irrigation in the Raft River basin is of direct concern to the public and public agencies. Federal agencies that administer the public lands need to know whether the perennial ground-water supply is sufficient to irrigate more than 30,000 acres of public land on which desert-entry and homestead applications have been allowed or were pending in 1956. About 20,000 acres of State-owned land might be sold to persons who plan to irrigate.

Data for this report were obtained during parts of several field seasons. The occurrence of shallow, unconfined ground water and deeper, confined (artesian) water; the relations of the water table in the Raft River valley to the channel conditions and regimen of the Raft and Snake Rivers and to the stages of Lake Walcott; the roles of precipitation, runoff, and ground-water recharge in the hydrologic cycle; and the relations of ground-water levels and fluctuations to the yearly withdrawals of ground water were studied.

Work in the Raft River basin included canvassing and measuring 420 wells, obtaining data on subsurface conditions, and making periodic measurements in observation wells. Thirteen wells were measured 1 to 12 times a year; recording gages were operated on five additional wells. Altitudes of many wells were determined with a spirit level in accordance with standards for third-order leveling. Bench marks of the U.S. Coast and Geodetic Survey furnished vertical control. Locations of most wells were determined by stadia traverse from section-corner markers. Pumpage data were collected for irrigation wells, and seasonal ground-water withdrawals were computed from records of electric-power consumption. Miscellaneous measurements of seepage

losses and gains in the Raft River between The Narrows 1 and Lake Walcott were made with a pigmy current meter. The discharges of Raft River at Peterson Ranch near The Narrows, about 8 miles southwest of Bridge, and of Clear Creek near Naf are measured by the Geological Survey, and these records are published annually in watersupply papers.

Wells were canvassed and ground-water levels were measured in 1948 by R. L. Nace, R. W. Mower, S. W. Fader, Eugene Shuter, and Glenn Brandvold. Leveling was done by R. W. Mower and S. W. Fader. Supplemental records were collected by H. G. Sisco during several periods from 1950 to 1955, and the pumpage records are virtually complete as of the end of the 1955 water year. Hydraulic coefficients were computed by J. W. Stewart from pumping tests. Several authors contributed sections to this report and are specifically credited in the table of contents and text. Sections not so credited are the work of the senior author.

The field investigations and preparation of the report were part of the program of water-resources investigations by the Geological Survey in cooperation with the Idaho Department of Reclamation.

LOCATION OF THE AREA

The drainage area of the Raft River basin is about 1,560 square miles. About 715 square miles is in the Raft River valley, which includes the principal potential irrigation area; about 740 square miles is in upstream and bordering tributary areas; and about 175 square miles is in the Snake River Plain (fig. 1). The plains tract does not have well-defined surface drainage and is not part of the Raft River surface-drainage basin. It extends from about the northsouth center line of R. 25 E. eastward to within 1 mile of the Raft River (pl. 1) and is bounded on the north by Lake Walcott and on the south by a line about half a mile north of T. 11 S. The boundary of the ground-water basin through R. 25 E. is arbitrary but includes all the area where recharge and underflow are derived largely from the Raft River basin. Much of the ground water west of the boundary consists of underflow from other areas.

About 270 square miles of the Raft River basin is in Box Elder County, Utah; most of the remainder is in Cassia County, Idaho, but a few square miles lies in Oneida and Power Counties, Idaho. The principal irrigable area is in Tps. 9 to 16 S., Rs. 26 to 27 E., in eastern Cassia County.

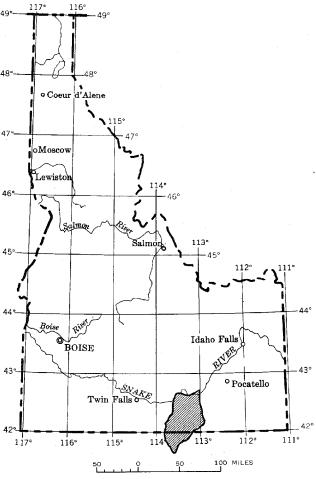


FIGURE 1.—Index map of southern Idaho and northern Utah, showing area covered by this report.

¹ Local geographic name for a gorge, about 2 miles long, cut by the Raft River through the south end of the Malia Range.

PREVIOUS INVESTIGATIONS

Several geologic studies have been made in the Raft River basin, and supplemental field studies were made by the senior author. Even so, the basic geologic information now available is not adequate for a complete hydrologic analysis of the basin. Although further investigation is needed, the information at hand is reasonably adequate for the purposes of this report.

Stearns and others investigated the Raft River Valley in 1928 as a part of a reconnaissance study of the ground-water resources of the entire Snake River Plain in Idaho. The results of that investigation, made by the Geological Survey in cooperation with the Idaho Department of Reclamation and the Minidoka Irrigation District, were incorporated in an unpublished preliminary report (Stearns, 1929) and in two published reports (Stearns and others, 1936, 1938). Kirkham (1931) compared the Tertiary stratigraphy of the Raft River basin with that of other areas in southern Idaho. Anderson (1931) described the general geology and mineral resources of eastern Cassia County, with special emphasis on the geology of upland areas, but he included relatively little information about the valley lowlands.

A preliminary report (Fader, 1951) on the Raft River basin contains records of wells, ground-water levels, and pumpage for irrigation. A report by Crosthwaite and Scott (1956) on ground water in the North Side Pumping Division of the Minidoka Project contains ground-water data that were used in preparing the present report. After fieldwork for the present report was completed, a report was published on the geology of the eastern part of the Raft River Range (Felix, 1956). A reconnaissance geologic map of Utah (Butler and others, 1920, pl. 4) covers the Utah part of the Raft River basin, but it is too generalized to be useful for this report.

ACKNOWLEDGMENTS

Well drillers furnished logs and other valuable information about wells. Residents and well owners supplied useful data about wells and permitted measurement of wells. The Raft River Rural Electric Cooperative furnished records of power consumption. The U.S. Bureau of Reclamation maintains and operates four recording gages on wells near the south side of Lake Walcott, and the records for these wells were available to the Geological Survey.

WELL-NUMBERING SYSTEM

Water wells are referred to in this report by numbers which indicate their locations within legal rectangular subdivisions of the public lands, with reference to the Boise base line and meridian. The first two segments of a number designate the township and range. The third segment gives the section number, followed by two letters and a numeral, which indicate the quarter section, the 40-acre tract, and the serial number of the well within the tract. Quarter sections are lettered a, b, c, and d in counterclockwise order, from the northeast quarter of each section. Within the quarter sections 40-acre tracts are lettered in the same manner. Thus, well 10S-25E-12ed1 is in the SE1/4SW1/4 sec. 12, T. 10 S., R. 25 E., and is the well first visited in that tract. The method of numbering is illustrated in figure 2.

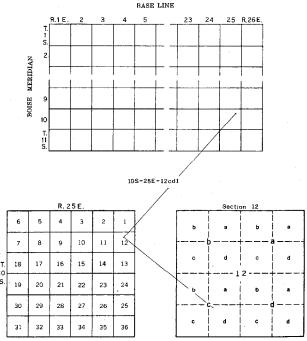


FIGURE 2.—Well-numbering system.

reduce or eliminate gains to the river from ground-water discharge, and increase percolation loss from the river by inducing infiltration. Pumping of ground water from shallow aquifers near the river, therefore, might be directly competitive with the use of surface water.

Pumping of ground water and increased consumptive use would deplete the water yield of the basin, and part of the depletion would be from surface flow. On the other hand, reasonable pumping of ground water need not infringe seriously on local surface-water rights. Pumping of ground-water, for instance, would not deplete streamflow during the pumping period unless the area of influence around pumped wells extended to the vicinity of the river and lowered the water table where ground water is effluent to the stream channel. Adverse effects would not be produced by (a) wells at a safe distance from the stream, (b) wells pumped only when there is excess water in the stream channel, (c) wells tapping deep aquifers that are not directly tributary to the river, or (d) wells pumped sufficiently late in the season that their effects on streamflow would occur after the principal surface-water diversions had been made.

Study would be necessary to determine the safe distance of wells from the Raft River. Such study should include analysis of representative pumping tests, observation of water-level fluctuations, measurements of stream discharge, and further geologic study. Linear distance would be very important for wells that tap shallow aquifers in which the ground water is hydraulically continuous with streams. Aquifers at intermediate depth, in which water occurs beneath partly confining or separating layers of impermeable material, could be tapped by wells without much risk of immediate or great effect on surface flows. Pumping of water from deep artesian aquifers would not affect surface flow directly if at all.

The wide area through which water is discharged to the Snake River Plain is an important factor in water use in the Raft River valley. Much of the ground-water underflow from the Raft River valley veers westward under the Northern Plains section south of Lake Walcott. Ground water in that area is not tributary to the Raft River except in a narrow belt on the east. Ground-water pumping in the Northern Plains section would have little or no effect on the discharge of the Raft River because the water there is outside the hydraulic system that controls the river.

Important competition for water will be confined largely to the Raft River basin, and downstream effects from developments in the basin will be immaterial. Minor regional competition for water, however, is a distant possibility. The Raft River surface drainage and part of the ground-water drainage are tributary to the Snake River near the head of Lake Walcott, and an unmeasured amount of water is contributed by the Raft River basin to the Snake River's main stem. The size of the contribution cannot be determined from surface inflow-outflow records of the reservoir, because ground water from other areas also is discharged to the river and lake above Minidoka Dam. Moreover, the downstream part of the lake loses water by percolation into the ground. River and reservoir records show that in the reach from Minidoka Dam to Neeley (about 25 miles upstream on the Snake River) the net gain to the river system is about 82,000 acre-feet in an average year (Crosthwaite and Scott, 1956).

Milner Dam, the farthest downstream large diversion dam for irrigation on the Snake River Plain, is a key point in river operation. The long-time average yearly surplus discharge of the Snake River past Milner Dam before construction of Palisades Dam was somewhat more than 1,000,000 acre-feet, and the maximum in any recent year was about 3,000,000 acre-feet. In some years of low runoff, spill past Milner was almost nil. In those years the entire yield of the Snake River system above Milner was stored or diverted for irrigation and there was a water shortage. The 10 to 12 years before 1956 were years of generally ample water supply, and substantial new depletion upstream probably would not have caused a shortage of water at or above Milner. New upstream storage works, notably Palisades Dam, will relieve shortages in future droughts, but surfacewater users are concerned that heavy pumping of ground water throughout the Snake River Plain may aggravate water shortages in years when runoff is low. Determination of the extent of such effect from pumping in any given area would be a major task, requiring careful study of extensive water data and thorough geologic investigation.

Some evidence indicates that at least some of the ground water that moves out of the Northern Plains section is not tributary to the Snake River above Milner, but passes beneath the river and joins a larger body of ground water north of the river. Ground water from that body is discharged to the Snake River through large springs below Milner Dam. The water discharged from the springs constitutes the principal flow of the Snake River between Milner and King Hill. Depletion of spring flow would decrease the amount of water available for generation of power by several hydroelectric installations in

SUMMARY OF PRINCIPAL CONCLUSIONS

The Raft River basin, hydrologically, is a unit area. The unit contains several subdivisions; in each of these the water supply is modest, but the aggregate amount is substantial. Ground-water underflow in all the subbasins is generally parallel to surface streamflow, and the Raft River valley is the master subbasin and collecting ground for the entire water yield of the basin. Runout from the valley moves northward to the Snake River Plain through a broad area at least 12 miles wide. Part of the water is discharged to the Snake River and to the upstream part of Lake Walcott. A large part, however, veers westward and probably moves into the Snake River Plain west of Minidoka Dam.

Nearly all usable surface water in the Raft River is diverted for full or supplemental irrigation of about 24,000 acres of land. Supplemental ground water is pumped for some of those lands. About 25,000 acres, chiefly in the lowland of the Raft River valley, is served partly or wholly with ground water. The total area irrigated in the entire basin is about 43,000 acres.

Ground water in the Raft River basin occurs in both unconfined and confined (artesian) aquifers. Much of the readily obtainable ground water of good quality is unconfined, occurring in lowland alluvial sand and gravel. In the Northern Plains section south of Lake Walcott, basalt is a copiously productive aquifer.

Fluctuations of ground-water levels in the Raft River lowland generally are moderate, the annual range being about 5 to 8 feet. During the 5-year period 1948-52 there was little net change in water levels, despite increased pumping of ground water, and water levels actually rose in a few wells during those years. After mid-1953 there was a small but steady net lowering of the water levels in most observed wells, amounting to about 1 to 2.5 feet at corresponding times of successive years. Much of the lowering probably would have occurred without ground-water pumping, owing to subnormal precipitation and deficient recharge. Deficient recharge is indicated by precipitation records and by the low water yield of springs and streams in uplands where there has been no pumping of ground water.

The water supply of the Raft River basin is derived from precipitation in the basin. No evidence was found to support the popular belief that a large amount of ground water enters the basin by migration from surrounding areas. The estimated total volume of precipitation is 1,290,000 acre-feet per year. About 1,105,000 acrefeet is consumed by basinwide natural evapotranspiration, and 44,000 additional acre-feet is consumed by crops. Surface outflow probably is less than 10,000 acre-feet. The estimated unconsumed total residual

water supply of 140,000 acre-feet per year is discharged from the basin by ground-water underflow and surface outflow. The conservatively estimated unused and uncommitted ground-water supply which leaves the basin by underflow probably is somewhat more than 130,000 acre-

Possibly as much as 100,000 acres of undeveloped land in the Raft River valley could be irrigated if a suitable water supply were obtained. The net consumptive-use demand for that land, assumed to be nearly 120,000 acre-feet yearly, over and above what would be satisfied directly by precipitation, would exceed the estimated water yield of the basin somewhat. The amount of uncommitted water that could be intercepted and used within the basin is the limiting factor in further development in the Raft River valley with its native water supply.

Existing irrigation wells in the valley yield 90 to 3,125 gpm; most wells yield more than 500 gpm, and very few yield less than 200 gpm. Well-performance tests and studies of well logs and well records indicate that the average coefficient of transmissibility of shallow aquifers in the lowland of the Raft River valley is on the order of 200,000 gpd per foot, and the coefficient for single aquifers may be much higher. Deeper aquifers also transmit a large volume of water yearly. A large percentage of properly situated and efficiently developed new wells in the Raft River Valley and Northern Plains section would be successful.

The 1955 pumping rate of 64,000 acre-feet of ground water per year probably could be safely increased sufficiently to irrigate 25,000 to 30,000 additional acres. If consumptive use on cultivated land were assumed to average 1.1 feet in addition to the natural consumptive use, with 73,000 acres under old and new irrigation, total water depletion in the basin would be about 1,180,000 acre-feet. The unconsumed residual water yield would be about 110,000 acre-feet. The water supply downstream on the Snake River would not be materially depleted.

The ground-water quality is not well known, but records show that water from some sources is doubtful to unsuitable for irrigation on some types of soil. The soil and the quality of water in the valley should be studied thoroughly.

Properly located wells in the Raft River valley would not seriously deplete the surface-water supply during the irrigation season if pumping were done on a moderate scale. Shallow wells near the Raft River might deplete the flow of the river below Peterson Ranch. Properly cased deep wells would not affect the river directly. Well users in most of the Northern Plains section would not compete with Snake River water users during the irrigation season, but wells adjacent to the Raft River or to the upstream part of Lake Walcott might be competitive to a very small extent in years of short water

The preliminary general conclusion is reached that sufficient uncommitted water is available and recoverable in the Raft River basin to irrigate about 25,000 to 30,000 additional acres of properly situated land.

Estimates in this report indicate that a moderate increase in irrigation would further deplete the water supply only moderately. However, this indication is the result of a series of estimates and extrapolations made on the basis of scanty data. The analysis of hydrologic factors and the estimates of water yield were made carefully, but the result is still only an estimate which probably will be revised in time.

Conservatism is advisable in further development in the Raft River basin. If the water yield estimated in this report is much higher than the actual yield, the consequence of rapid exploitation might be unfortunate. Overdevelopment might occur before positive symptoms of it were detected by hydrologic means, but the authors believe that development on the scale suggested above would be conservative. If increased draft on the water supply were made in increments of a few thousand acre-feet per year, it would be feasible by hydrologic means to detect symptoms of overdevelopment before it became excessive. Two factors will potentially limit the development: the amount of water available, and the amount of the available supply that can be recovered economically from wells.

SUGGESTIONS

The total water supply in the Raft River basin is far from adequate for all irrigable land in the Raft River valley. The disparity between the amounts of land and water is so great that the inadequacy would remain even with optimum use of the total supply. The effective supply may exceed the accessible supply somewhat because unconsumed irrigation water may be reused. The effective supply might be increased also by artificial recharge—spreading surplus winter and freshet flow in selected areas. The amount of water available for artificial recharge is small, because surface runoff at the mouth of the Raft River averages only a few thousand acre-feet per year. Additional study would be required to determine the physical and economic feasibility of artificial recharge with surplus surface water.

Imported Snake River water also might be used for artificial recharge. Moderate excess winter flows are anticipated in the Snake River in some years, even with the new storage capacity at Palisades

Dam near the Wyoming border. In the existing pattern of water use, excess water would spill unused past Milner Dam. The possibility of diverting some of the excess to the Raft valley for artificial recharge of ground water seems to be worth study. The necessary diversion and transmission works probably would not be expensive because much transmission loss by percolation into the ground could be tolerated. Such loss could be counted as an artificial-recharge benefit if it occurred in areas where the ground water is usable. A principal problem probably would be canal ice in winter. Ice in water-spreading fields would not necessarily be undesirable because the ice would delay actual recharge until spring, when it would do the most good.

The water situation in the Raft River valley illustrates that, to achieve optimum development of water in some situations it may be necessary to broaden water rights so that they apply to all water, whether from surface or underground sources.

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